UNDERSTANDING RENEWABLE ENERGY
THE POWER SYSTEM

Presenter: Crescent Mushwana, Research Group Leader, Energy Systems
Council for Scientific and Industrial Research, South Africa

Video Transcript

[TEXT: Young African Leaders Initiative Online Training Series]

[TEXT: Crescent Mushwana, Research Group Leader, Energy Systems
Council for Scientific and Industrial Research, South Africa]

[TEXT: Understanding Renewable Energy The Power System]

I'm Crescent Mushwana from South Africa's Council for Scientific and Industrial Research. This is "The Power System."

In this lesson, we will learn how power systems operate, how power companies and their system operators can use renewable energy sources to meet the needs of their customers, and what countries can do to guarantee that their renewable energy-based power supplies are available when and where they need them.

Previously, we looked at the rapid growth of renewable energy and saw that wind and solar energy are now cost competitive with traditional energy sources in many places. So why haven't we abandoned fossil fuels and converted our energy systems to run solely on renewables? To answer that question, we must first understand how energy systems operate.

Every power system – or "grid" as we call it – is made up of three main components: generation, transmission, and distribution In the traditional model, the utility company builds large, centralized power plants to generate electricity. The electricity is then sent over high-voltage transmission lines to substations where the voltage is reduced. Then the power is distributed to homes and businesses. That energy being used by homes and businesses at any given time is collectively known as the "load." And the load is constantly changing. Every time you turn on a light switch, it increases the load. And when you turn off the lights, the load goes down.

If you look at the energy consumption of people across a city, you see broad trends develop. Like where the energy goes down at night when most people are asleep, but rises during the day when more people are up and about. The period of minimum energy demand required to keep the city running is known as the "base load," and the period of highest demand is known as the "peak load." If you are a utility company, it is very important to understand these trends, because the amount of energy you feed into the grid at any time must match the load. If you don't provide enough, you have a brownout or loss of power.

Every utility has system operators whose job it is to monitor the changing load and ensure that they are providing just enough electricity to meet demand. They create complex models to help them forecast future demand and ensure they have generation capacity ready to dispatch as demand rises. They need to know that they have a steady, reliable energy source to cover the base load — that minimum amount of energy that's needed 24 hours a day — and generators they can dispatch on demand to meet the peak load. This is how the traditional power system is operated.

But if solar panels can only generate electricity when the sun is shining and wind turbines can only turn when the wind is blowing, how do you guarantee that energy's available when you need it?

Renewable energy introduces a new challenge to the system operator's work. By their very nature, renewables are variable sources of energy. So the system operator is now juggling variable supply *and* variable demand.

How do you incorporate renewables into the system without upsetting the balance? There are a few tools available that help. First, let's look at tools to manage the supply side of the energy equation.

The most basic tool for anticipating the supply of renewable energy at any given time is the weather report. As weather forecasting improves, system operators are better able to predict when they can rely on solar panels and wind turbines. Weather forecasting models are used as input into forecasting models for wind and solar supply. If weather conditions look unfavorable for renewables, and the renewables forecasting models show that the supply will be low, the system operator can turn on back-up generators such as gas turbines, which can be turned on and off very quickly.

The second way to alleviate the problem of local fluctuations in energy production is to have generation resources distributed over a large geographic area. If the system operator is dependent on solar panels in a single location, a passing cloud could knock out his energy supply. But if he's pulling from panels across a large region, those small local fluctuations even out across the larger system. After studying the distribution of generation facilities and weather patterns across the entire generation area, we can develop reliable models to anticipate local energy fluctuations and strategies for balancing them out across the system.

In addition, coupling renewables with storage mechanisms removes the variability question from the equation altogether. We already have numerous types of storage built into traditional power grids around the world. By using these tools to store renewable energy, we can ensure that energy is available whenever it's needed. Magnetic flywheels store power as rotational energy. Pumped hydro storage carries water uphill to a reservoir from which it can be released to drive a turbine as it flows downhill. Compressed air storage compresses air into an underground cavern from which it can be released to drive a turbine. And of course, energy can be stored in batteries. Wind turbines and solar panels can feed energy into storage devices during periods of low demand. That energy can be released whenever demand rises.

On the demand side of the energy equation, we are now developing digital tools that will allow the system operator to monitor and manage energy usage at the point of consumption. This is called "smart grid" technology. These tools allow the system operator to optimize the operation of smart appliances and consumer devices, switching them to energy-efficiency mode during load spikes, and drawing on energy-storage resources such as electric car batteries plugged into the grid as needed. This is exciting new technology that will help the system operator balance both sides of the energy equation.

Historically, most countries haven't invested heavily in storage capacity because fossil fuels could be dispatched on demand. But some countries are now successfully managing high penetration of renewable energy on their power systems — even with limited grid-storage capacity. For example, 42 percent of the electricity Denmark consumed in 2015 came from wind. To be sure, Denmark's grid is interconnected with neighboring countries upon which it can draw if its supplies drop, but it still serves as an example of how system operators can integrate large amounts of renewable energy into their grid. And as countries like the United States and Germany invest heavily in grid storage as part of an effort to enable even greater reliance on renewables, technologies are improving and prices are dropping. These trends are paving the way to a 100 percent renewable future for all countries.

So what can you as an individual do to help facilitate our transition to a modern energy system based on renewables? We'll look at that in another lesson.

After you've completed all the lessons in this course at YALI.state.gov, you can test your knowledge and earn a YALI Network certificate.

[TEXT: Test your knowledge, YALI.state.gov]

[TEXT: Produced by the U.S. Department of State]